Coralliophila trigoi (Gastropoda: Muricidae), a new species from the northeastern Atlantic Ocean

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ABSTRACT

Based on shell characters and with further support from molecular data, *Coralliophila trigoi*, a new species of gastropod of the family Muricidea, is here described from the northeastern Atlantic Ocean. The new taxon, consisting of several specimens mainly collected along the Atlantic Spanish coast, has previously been misidentified in the literature as *Coralliophila basilea* (Dautzenberg and H. Fisher, 1896). *Coralliophila trigoi* new species is conchologically similar to *Coralliophila meyendorffii* (Calcara, 1845), and *Coralliophila panormitana* (Monterosato, 1869), but it can be easily separated from them mainly because it is differently sculptured. The new species is compared with other members of the genus *Coralliophila* from the same geographical area and Mediterranean Sea. Molecular sequencing of the internal transcribed spacer 2 region (ITS2) of the nuclear rDNA and part of the mitochondrial gene for 12S rDNA confirm the validity of the new species.

INTRODUCTION

The coralliophilines form a monophyletic group of neogastropods that includes approximately 200–250 described species grouped, based on their shell morphology, in at least 7–10 "genera", distributed worldwide in temperate and tropical oceans. The subfamily Coralliophilinae Chenu, 1859 (for the phylogenetic relationship of this muricoidean groups, see Oliverio and Mariottini, 2001a) includes species invariably associated with cnidarians, which are generally used as food by the gastropods. Shell variability, absence of radula, absence of a preserved protoconch (often eroded in adults and even in young specimens), together with a limited knowledge of the anatomy, represent constrains to the understanding of the taxonomic status of this group of neogastropods. Their classical systematics above the species level is at present far from being stable (Clover, 1982; Bouchet and Warén, 1985; Kosuge and Suzuki, 1985; Oliverio, 1989; Vaught; 1989; Oliverio, in press). Data from mitochondrial and nuclear genes (12S rDNA and ITS2 rDNA, respectively) have been recently utilized in the proposal of a molecular framework for the phylogeny of these muricids (Oliverio and Mariottini, 2001a; Oliverio, Cervelli and Mariottini, 2002). Data from both sequence and secondary structure show that Rapaninae Gray, 1853 (=Thaidinae Jousseaume, 1888) are their sister group (Harasewych et al., 1997; Oliverio and Mariottini, 2001a; Oliverio, Cervelli and Mariottini, 2002), indicating a monophyletic radiation of the Coralliophilinae. The state-of-the-art knowledge about feeding, anatomy, sexual strategies, parental care, and protoconch of coralliophilines was recently reviewed by Richter and Luque (2002). The authors reported the available data on protoconch and larval development of many coralliophilines belonging to ten different genera, including *Coralliophila* H. and A. Adams, 1853. We had the opportunity to examine several shells of a coralliophiline that we could allocate to any of the Atlantic and Mediterranean species of this subfamily. These shells, mostly collected along the coast of Galicia, Spain, were previously misidentified in the literature as *Coralliophila basilea* (Dautzenberg and H. Fisher, 1896) (Rolán, 1983; Rolán, López and Gutiérrez-Garcia, 1995). After comparisons with other species, we realized that they represent an undescribed species, possibly related to *Coralliophila meyendorffii* (Calcara, 1845) and *Coralliophila panormitana* (Monterosato, 1869).

In order to verify the taxonomic validity of *Coralliophila trigoi*, we carried out molecular sequencing of the internal transcribed spacer 2 region (ITS2) of the nuclear rDNA and of part of the mitochondrial gene for 12S rDNA. Genomic DNA was extracted from the dissected foot of two freshly collected individuals with standard methods (SDS-proteinase K digestion, phenol/chloroform extraction, ethanol precipitation (Oliverio and Mariottini, 2001b)). Mitochondrial rDNA was amplified through the polymerase chain reaction (PCR) with primers *12S-I* and *12S-III* (Oliverio and Mariottini, 2001a). Nuclear ribosomal ITS2 was amplified using the primers

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Table 1. Collecting data and DDBJ/EMBL/GenBank accession number for specimens assayed in molecular systematics.

Species/individuals	Collecting locality and depth	Accession number	
		12S	ITS2
Coralliophila neritoidea	Taiwan, 23°10′ N, 120°05′ E, 5 m depth	AJ293679	AJ420258
Coralliophila brevis	La Maddalena Is. (Sardinia, Italy), 41°15′ N, 009°26′ E, 30 m depth	AJ293676	AJ420256
Coralliophila mejendorffii	La Maddalena Is. (Sardinia, Italy), 41°15′ N, 009°26′ E, 3–7 m depth	AJ297517	AJ293661
Coralliophila panormitana	Cape Circeo (Latium, Italy), 41°11′ N, 013°04′ E, 70 m depth	AJ293681	AJ420259
Coralliophila trigoi new species, specim. #1	Camariñas, Galicia, Spain, northeastern Atlantic Ocean, 15–50 m depth	AJ937305	AJ937307
Coralliophila trigoi new species, specim. #2	Camariñas, Galicia, Spain, northeastern Atlantic Ocean, 15–50 m depth	AJ937306	AJ937308

its-3d and *its-4r* complementary to conserved regions of the ribosomal coding portions on the 5.8S and 28S rRNAs (Oliverio and Mariottini, 2001b). PCR-amplified products were directly sequenced by an automated sequencer. Nucleotide sequences were first aligned by hand and the alignment progressively optimized according to secondary structure homology. Phylogenetic analyses were performed using PAUP* 4b10 (Swofford, 2002). GenBank accession numbers (12S and ITS2) of the *Coralliophila trigoi* sequences are reported in Table 1.

Institutional abbreviations used: MNCM, Museo Nacional de Ciencias Naturales, Madrid, Spain; MZB, Laboratorio di Malacologia, Museo di Zoologia dell'Università di Bologna, Italy.

Abbreviations used for collections: CS-PM, Carlo Smriglio and Paolo Mariottini (Rome, Italy); ER, Emilio Rolán (Vigo, Spain); FS, Frank Swinnen (Lommel, Belgium); JT, Juan Trigo (Brion, A Coruna, Spain); MO, Marco Oliverio (Rome, Italy).

SYSTEMATICS

Superfamily Muricoidea Rafinesque, 1815
Family Muricidae Rafinesque, 1815
Subfamily Coralliophilinae Chenu, 1859
Genus *Coralliophila* H. and A. Adams, 1853

Type Species: *Fusus neritoideus* Lamarck, 1816, Ency. Meth., pl. 435, figs. 2a–b. (=*Purpura violacea* Kiener, 1836), by subsequent designation (Iredale, 1912). Recent, Indo-Pacific.

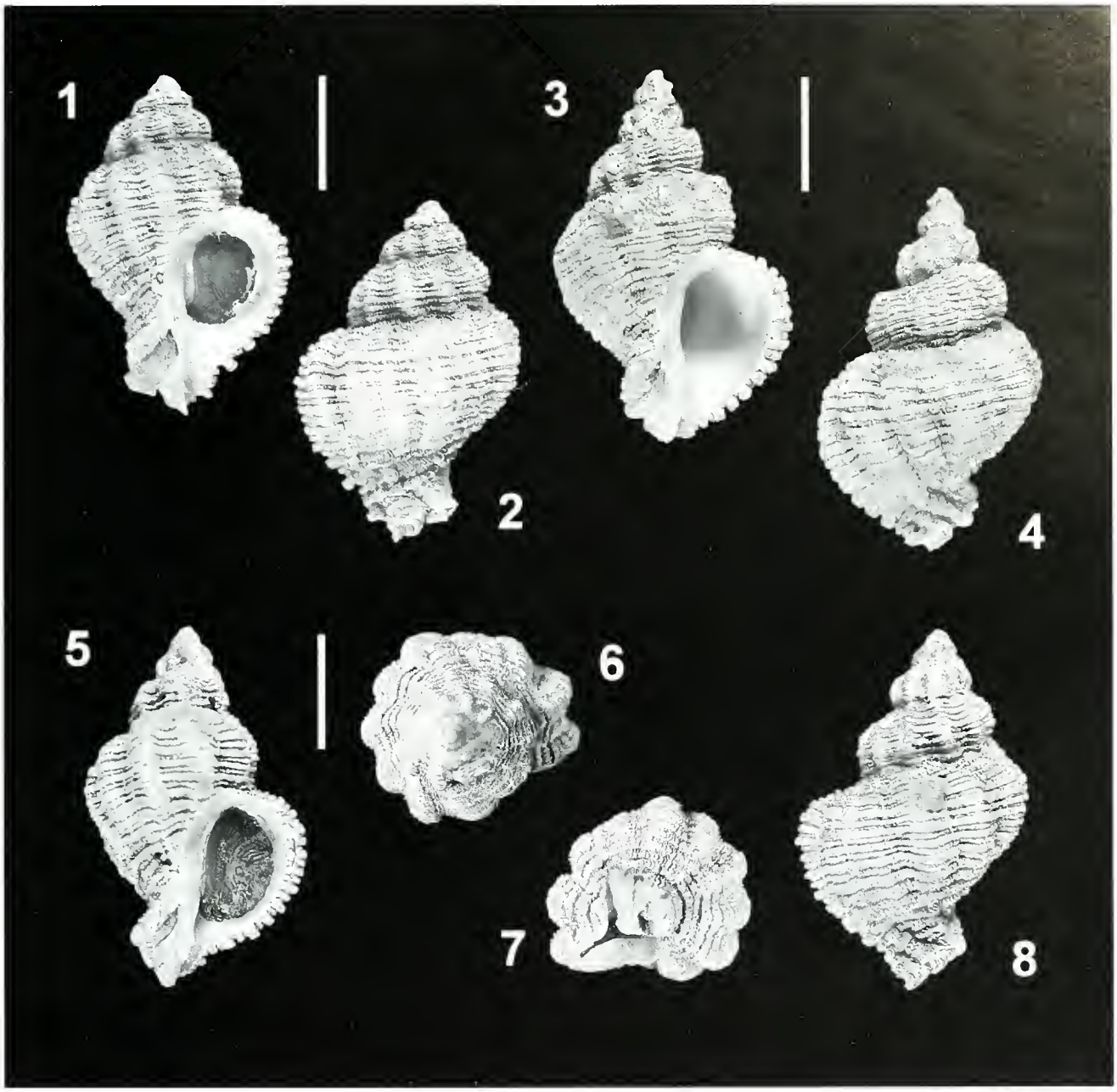
Coralliophila trigoi new species
(Figures 1–8, 13–14, 17–21)

Description: Shell of large size, up to 35 mm length. Protoconch usually eroded in adult specimens (protoconch observed in only one juvenile specimen, albeit worn and lacking the embryonic stage). Protoconch indicative of planktotrophic larval development, multispiral, composed of protoconch I and II. Protoconch II of about 2½ whorls, with a diameter of about 800 μm, showing two strong spiral keels, only one visible above the suture of the first whorl, crossed by axial ribs forming nodules at intersections. The protoconch-teleoconch demarcation is well-defined, marked by a varix. Teleoconch shape biconical, elongate ovoid-fusiform, solid, rather inflated. Spire relatively high, conical, 4–5 rather convex whorls, shoulder rounded. Suture not very evident, partially covered by the sculpture, which is formed of 15–20 spiral cords, regularly ordered, rarely alternating with smaller spiral cords. Spiral sculpture consisting of ribs rounded in cross-section, all of similar width, densely covered with imbricating, fine, and long lamellae. Axial ribs 7–11, large, generally weak, crossing the spiral cords. Siphonal canal short, narrow, open, moderately curved. Aperture large, oval, representing about half of the shell height, white or cream-white inside. Umbilicus absent. Outer lip thin and crenulate. Shell color uniformly reddish- or pale-brown. Operculum oval, oblong, horny, concentric, with lateral-terminal nucleus, reddish-brown.

Type Material (Figures 1–8): Holotype (Figures 1–2), 30.6 × 20.4 mm, MNCN 15.05/46458; paratype A (Figures 3–4), 31.6 × 19.4 mm, MZB 31023; paratype B (Figures 5–8), 27.3 × 16.7 mm, CS-PM; paratype C, 27.4 × 18.2 mm, CS-PM; paratype D, 24.2 × 16.8 mm, ER; paratype E, 26.8 × 16.6 mm, ER; paratypes A–E, from type locality; paratype F, 30.9 × 18.5 mm, ER, Malpica, Spain; paratype G, 23.5 × 16.3 mm, ER, Camelle, Spain; paratype H, 24.8 × 17.3 mm, JT; paratype I, 21.2 × 12.3 mm, JT; paratype L, 26.9 × 17.1 mm, JT; paratype M, 21.4 × 12.3 mm, JT; paratype N, 31.2 × 18.0 mm, JT; paratype O, 18.5 × 12.8 mm, JT; paratype P, 7.4 × 5.1 mm, CS-PM; paratypes H–P from Porto da Baleeira, Sagres, Portugal; paratype Q, 30.2 × 18.1 mm, ER, Lira A Coruña, Spain; paratype R, 26.4 × 17.2 mm, ER, Malpica, Spain; paratype S, 27.3 × 16.2 mm, CS-PM; paratype T, 25.1 × 16.2 mm, CS-PM; paratypes Q–T from Lira A Coruña, Spain; paratype U, 39.2 × 23.2 mm, CS-PM, A Guarda, Spain; paratype V, 30.1 × 18.6 mm, CS-PM, type locality; paratype W, 29.8 × 17.4 mm, CS-PM; paratype Z, 25.8 × 16.2 mm, CS-PM; paratypes W–Z from Malpica, Spain.

Type Locality: Camariñas, Galicia, Spain, northeastern Atlantic Ocean, 15–50 m depth.

Distribution: Known from Galicia, Spain, to Algarve, Portugal, in the Atlantic Ocean, and from Malaga and Almeria (Alboran Sea, Spain) in the Mediterranean.

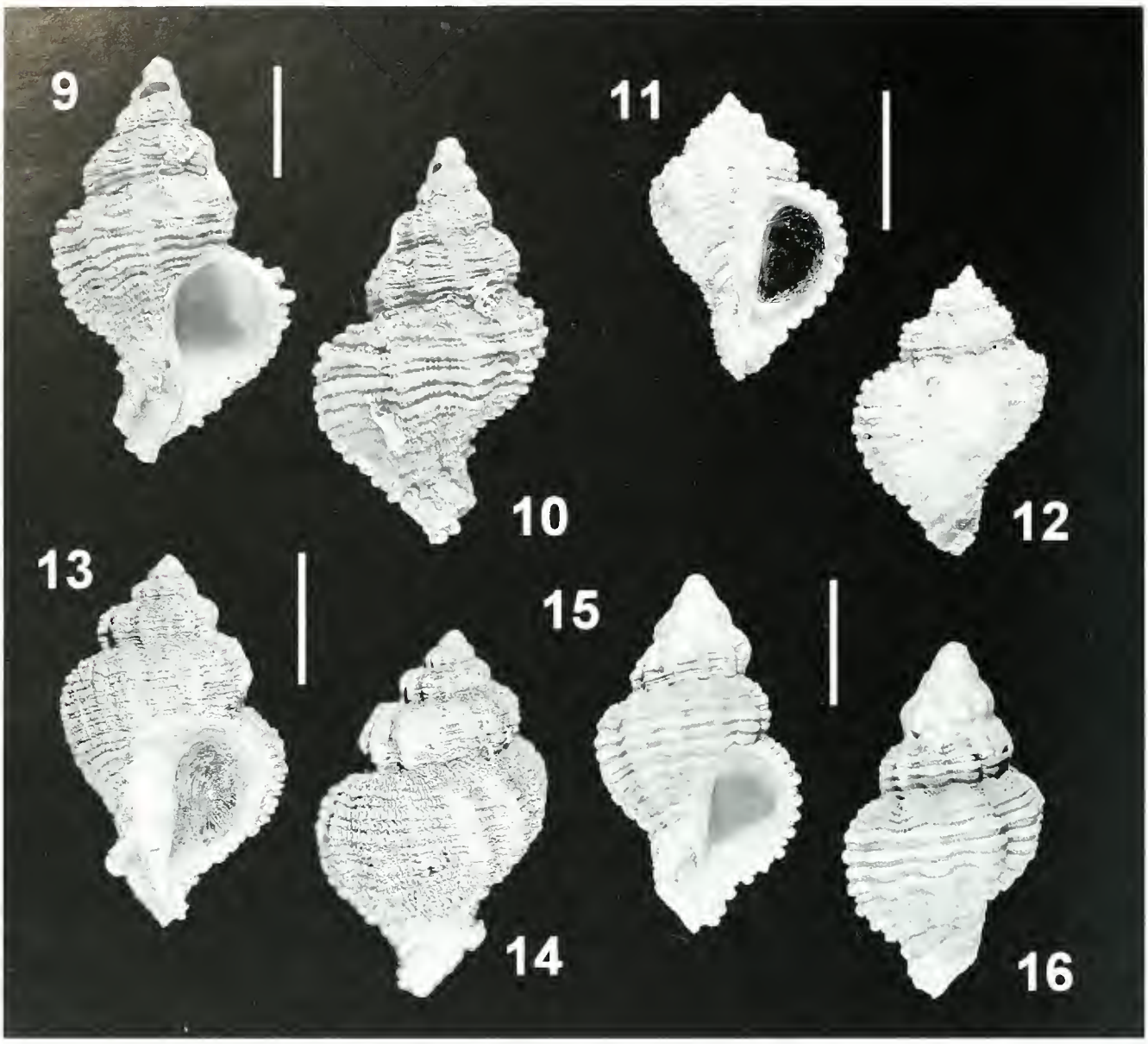


Figures 1–8. *Coralliophila trigoi* new species. **1–2.** Holotype, 30.6 × 20.4 mm, MNCN 15.05/46458. **3–4.** Paratype A, 31.6 × 19.4 mm, MZB 31023. **5–8.** Paratype B, 27.3 × 16.7 mm, CS-PM. From type locality, depth 15–50 m. Scale bars = 1 cm.

Habitat: Several live collected specimens were found attached at the base of host cnidarians *Calliactis parasitica* (Couch) (a sea anemone).

Etymology: This species name is dedicated to our friend Juan Trigo, who supplied some of the specimens of the new species.

Molecular Sequencing: Given the often misleading information conveyed by characters of shell morphology in this group (Oliverio and Mariottini, 2001b), we verified the validity of the new species using a molecular approach. We sequenced the internal transcribed spacer 2 region (ITS2) of the nuclear rDNA and part of the mitochondrial gene for 12S rDNA from individuals of the new taxon and compared them with available sequences of *C. meyendorffii*, *C. panormitana*, and *Coralliophila brevis* (Blainville, 1832), plus *Coralliophila neritoidea* (Lamarck, 1816) as outgroup. Parsimony analysis of the aligned sequences of nuclear and mitochondrial DNA resulted in the tree reported in Figure 27.

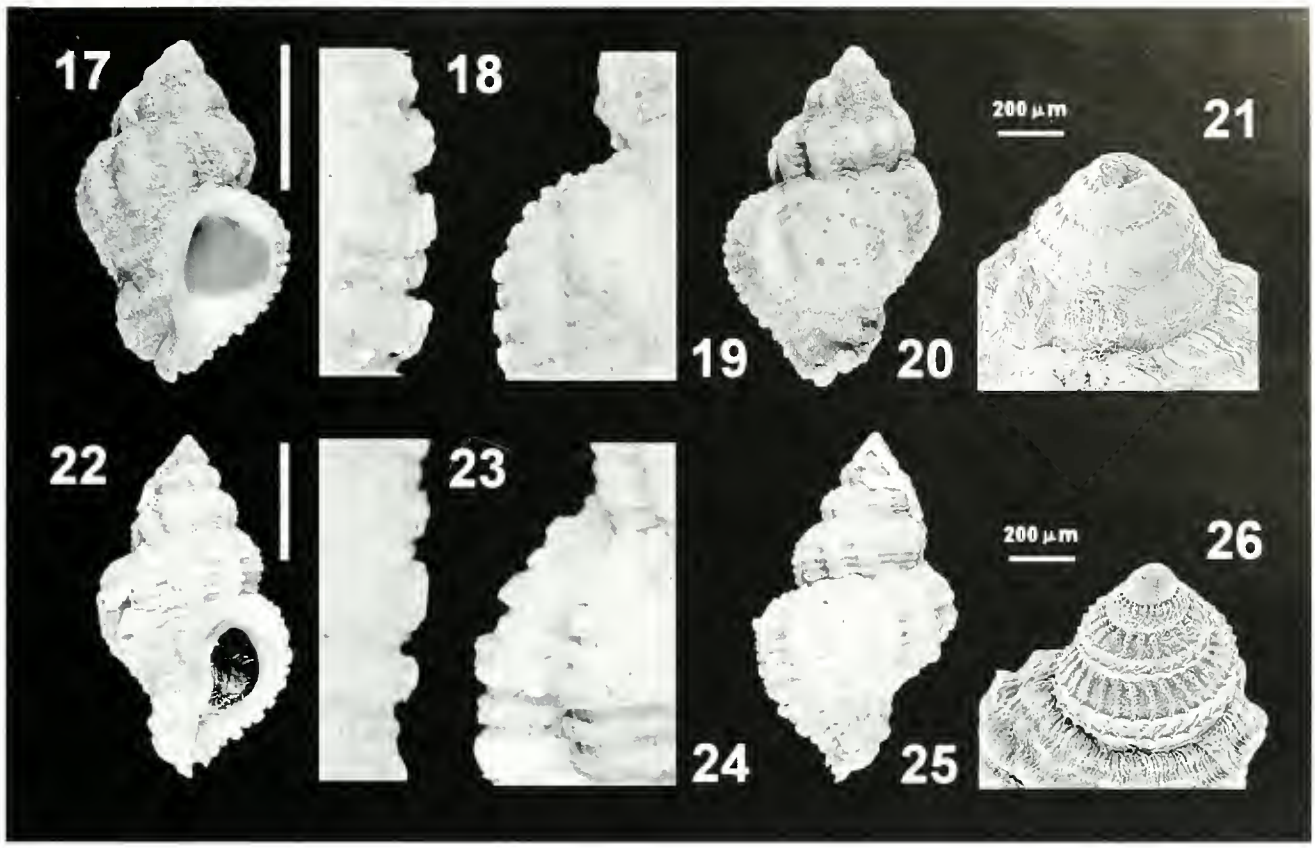


Figures 9–16. Shells of *Coralliophila* species. **9–10.** *Coralliophila squamosa* (Bivona, 1838), 35.9 × 20.9 mm, CS-PM, Camariñas, Galicia, Spain, 15–50 m depth. **11–12.** *Coralliophila panormitana* (Monterosato, 1869), 19.2 × 12.1 mm, CS-PM, Malaga, Spain, 40 m depth. **13–14.** *Coralliophila trigoi* new species, 27.2 × 18.1 mm, MO, Marbella, Spain, 30–50 m depth. **15–16.** *Coralliophila meyendorffii* (Calcara, 1845), 26.8 × 14.7 mm, FS, Punta del Carmen, Lanzarote Isl., Canary Islands, 20 m depth. Scale bars = 1 cm.

The two related species *C. meyendorffii* and *C. panormitana*, were more closely related to each other than to the two specimens of the new species.

Other Material Examined: *Coralliophila trigoi:* 5 spec. from the type locality; 3 spec., Laxe; 1 spec. A Guarda; 3 spec. Camelle; 3 spec. Malpica, Galicia, Spain, ER; 2 spec. Sagres, Algarve, Portugal, CS-PM; 2 spec. Almeria; 3 spec. Marbella, Spain, MO; *Coralliophila meyendorffii:* 10 spec. La Maddalena Isl., Sardinia Island; 1 spec. San Pietro Isl., Sardinia Island; 6 spec. Santa Marinella; 3 spec. Ponza Isl.; 1 spec. Capo Palinuro; 3 spec. Le Castella; 5 spec. Elba Isl., Italy, CS-PM; 6 spec. Punta del Carmen, Lanzarote Isl., Canary Islands, FS; *Coralliophila panormitana:* 5 spec. Marina di Camerota, Italy; 1 spec. Malaga, Spain; 1 spec. Portimão, Portugal, CS-PM; *Coralliophila squamosa:* 23 spec. from the type locality; 6 spec. Laxe; 8 spec. Camelle; 7 spec. Malpica, Galicia, Spain, ER; 10 spec. Ría de Vigo, Galicia, Spain, JT; 1 spec. Malaga, Spain; 1 spec. San Pietro Isl., Sardinia Island; 1 spec. Ventotene Isl.; 1 spec. Marina di Camerata; 2 spec. Le Castella; 2 spec. Civitanova Marche, Italy, CS-PM.

Remarks: Based on shell characters of the teleoconch we take the conservative approach of conserving this



Figures 17–26. Shells of *Coralliophila* species. **17–20.** *Coralliophila trigoi* new species, 23.6 × 14.0 mm, CS-PM, Algarve, Portugal. **18, 19.** Details of shell sculpture. **21.** *Coralliophila trigoi* new species, detail of the larval whorls, paratype P, 7.4 × 5.1 mm, CS-PM, Porto da Baleeira, Sagres, Portugal, 15–25 m depth. **22–25.** *Coralliophila meyendorffii* (Calcara, 1845), 28.6 × 16.0 mm, CS-PM, La Maddalena Isl., Sardinia, Italy, 1 m depth. **23, 24.** Details of shell sculpture. **26.** *Coralliophila meyendorffii*, detail of the larval whorls, specimen size 2.2 × 1.3 mm, CS-PM, La Maddalena Isl., Sardinia, Italy, 1 m depth. Scale bars = 1 cm, except for Figures 21, 26, scale bars = 200 µm.

species in the genus *Coralliophila* s. l., as traditionally formulated (see also Oliverio, in press). The new species was collected in Galicia together with the Atlantic-Mediterranean *Coralliophila squamosa* (Bivona, 1838). This latter species is generally collected in the Mediterranean Sea at depths ranging from 100 to 600 m (Figures 9–10). The new taxon is clearly conchologically distinguishable from all other eastern Atlantic and Mediterranean species of Coralliophilinae. *Coralliophila trigoi* shows a certain resemblance with the Mediterranean *Coralliophila panormitana* (Monterosato, 1869), but the latter is smaller, having a different sculpture that includes a larger number of spiral cords (22–24), with smaller scales (Figures 11–12).

Coralliophila trigoi is similar to *Coralliophila meyendorffii* (Calcara, 1845) (Figures 15–16, 22–26), but it differs by its more rounded shape, by having the length/width and length/aperture length ratios smaller (1.60 and 1.68 vs. 1.72 and 1.86), by possessing a larger number of primary spiral cords (15–20 vs. 13–15), which are narrower in width and differently sculptured, and by a reddish- or pale-brown color (*Coralliophila meyendorffii* is generally milky-white). Furthermore, the protoconch II of *Coralliophila trigoi* shows a number of whorls (2½) and a diameter (800 µm) different from the values on *Coralliophila meyendorffii* (3½ and 650–750 µm, respectively; see Figures 21, 26). The main shell morphological differences between these two species are summarized in Table 2. *Coralliophila meyendorffii* is a littoral, widely distributed species, occurring in the Mediterranean Sea (Figures 22–26), along the Atlantic African coast and Canary Islands (Figures 15–16). It is worth mentioning that *Coralliophila meyendorffii* preys on a variety of anthozoans, including the cnidarian *Calliactis parasitica* (personal observations). Interestingly, *Coralliophila trigoi* seems to be distributed along the Atlantic coast of Spain and Portugal, but restricted to the Alboran Sea (Malaga, Almeria) within the Mediterranean basin. The collecting depth is slightly deeper (50 m) than the bathymetric range (littoral) of *Coralliophila meyendorffii*. Although the planktotrophic mode of development (as indicated by the protoconch) of *Coralliophila trigoi* could bring about a wider geographic distribution than that currently known for the species, the taxon has not yet been found in the Macaronesian Islands and the West African coast.

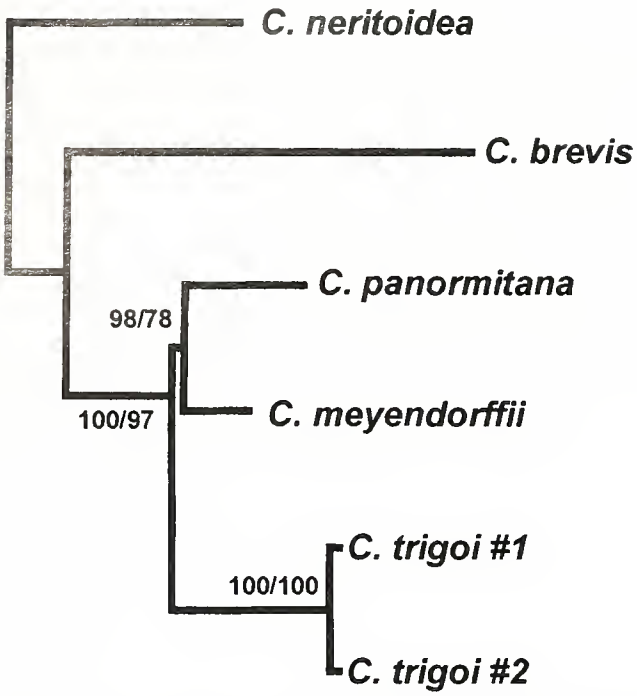


Figure 27. Cladogram of parsimony analysis for the studied coralliophiline taxa. This topology was recovered under maximum parsimony analysis of the 12S + ITS2 dataset (either including or excluding gap positions). Numbers at the branch represent bootstrap support in MP analyses (gap included and gaps as missing). Locality data and GenBank accession numbers (12S and ITS2) are reported in Table 1.

Coralliophila trigoi has been previously misidentified as *Coralliophila basilea* (Rolán, 1983: 236, fig. 240; Rolán, López and Gutiérrez-Garcia, 1995: 30, fig.2), but it is easily distinguishable from this taxon. *Coralliophila basilea* has a more turreted shell and a coarser spiral sculpture. Among the fossil coralliophiline records, the only species that slightly resembles the new taxon is *Coralliophila burdigalensis* (Tournouër, 1874), a species from the Upper Oligocene and Lower Miocene of Aquitaine (France); but the fossil species is smaller and has a different shell outline and sculpture (Lozouet and Renard, 1998: 173, figs. 2. 1–10).

Parsimony analysis of the aligned sequences of nuclear and mitochondrial DNA resulted in the tree reported in Figure 27. Accordingly, the two related species *C. meyendorffii* and *C. panormitana* were more closely related to each other than to the two specimens of the new species. The same results (not shown here) were obtained including additional (yet shorter) sequences of *C. meyendorffii* from other Mediterranean localities (Sardinia, Sicily, and Southern Spain). This is a clear indication that the specimens of the new form constitute a distinct, isolated gene-pool and strongly support our decision to describe it as new.

Table 2. Comparison of shell characters between *Coralliophila trigoi* and *C. meyendorffii*.

Shell characters	*C. trigoi*	*C. meyendorffii*
Protoconch diameter	800 μm	650–750 μm
Protoconch number of whorls	2.5	3.5
Teleoconch primary spiral cords	15–20	13–15
Teleoconch axial ribs	7–11	8–10
Length/width ratio	1.60 ± 0.09	1.72 ± 0.09
Length/aperture length ratio	1.68 ± 0.10	1.86 ± 0.10
Size range	17.6–35.4 mm	19.5–34.3 mm

ACKNOWLEDGMENTS

We would like express our deep gratitude to Mr. Juan Trigo, Brion, A Corrna, Spain, for kindly sending us specimens of *Coralliophila trigoi*. Dr. Andrea Di Giulio (Department of Biology, University of "Roma Tre", Rome, Italy) is acknowledged for SEM photographs, which were carried out at the LIME (Inter-Department Laboratory of Electron Microscopy, University of "Roma Tre"). Sincere thanks are due to Dr. Antonio Bonfitto (Zoological Museum, University of Bologna, Italy) for generously providing bibliography. We are grateful to Drs. Marco Oliverio and Maria Vittoria Modica (Department of Animal and Human Biology, University of "La Sapienza", Rome, Italy) for help with molecular work. M. Oliverio also provided valuable advices and discussion.

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